

Comment

Ontogenetic growth: Schmalhausen or von Bertalanffy? Comment on “Physiologic time: A hypothesis” by D. West and B.J. West

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The paper [1] is very interesting and important for the biology of development. This is primarily due to the range of the topics involved: physiological and physical (chronological) times, allometry, metabolism, and growth rate. However, there have already been investigations that attempted to connect the above concepts. These papers are partially presented in the large bibliography [1] or, for instance, in [2]. What is so specific about this paper? In my opinion, it is the involvement of the Shannon information entropy and the hypothesis that the fluctuations in the total body mass are described by a scaling probability density. This allows obtaining a very interesting result, which was not noted by D. West and B.J. West in the paper. Indeed, from the comparison of Eq. (34) and Eq. (37) (or Eq. (35) and Eq. (36)) it follows that the average total body mass (m) is a homogeneous function of the chronological time (t), i.e.:

$$m \propto t^{\xi} \quad \text{or} \quad \frac{1}{m} \frac{dm}{dt} \propto \frac{\xi}{t}, \quad (1)$$

where ξ is some constant.

This relation is interesting for the following reason. There is a long-standing discussion on the mathematical representation of the ontogenetic growth models in the literature: is the rate of the body-mass change (dm/dt) an *explicit* function of time or not? I. Schmalhausen (1927–1935) was one of the originators of the models similar to Eq. (1), whereas L. von Bertalanffy (1957) did much to prove that dm/dt does not depend on time explicitly (see Ref. [37] and Ref. [83] in the commented paper, respectively). Let us note that now there is a prevailing number of biologists supporting the von Bertalanffy approach; therefore, D. West and B.J. West should expect their criticism. For my part, I can support Eq. (1) and advance the following additional argument for it. Let us consider growth in an environment that is both time-independent and has infinite sizes. The case is valid, for instance, for the embryonic growth (the one I. Schmalhausen has originally intended his model of Eq. (1) type for). For such a formulation, the problem has no characteristic scales of mass and time. Due to the lack of the internal scale, the dependence $m(t)$ cannot be, for example, exponential (such a dependence follows from the models similar to those of von Bertalanffy) at least based on

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the considerations of dimensional analysis [3]. As is known, the main attribute of power laws is their scale invariance and therefore $m \propto t^\xi$.

In conclusion, we would like to give two non-essential remarks to the authors of the paper [1].

1. In view of the above reasoning and based on the known empirical facts, it is obvious that the function $m(t)$ of Eq. (1) form is valid only within a finite time interval. The authors have not established the applicability limits of the hypothesis (Sections 1.3 and 3.1) and the developed theory. However, this problem is very important.
2. Sections 3 and 4 deal with the connection between minimum entropy generation and maximum efficiency in physiological phenomena. The description here lacks due rigor. The fact is that, when discussing the maximum efficiency in physiological phenomena (see [5] in the commented paper), the production of *thermodynamic* entropy, which is connected with the heat of dissipation [4,5], is employed. However, the authors of the paper employ the typical Shannon information entropy that only formally resembles the Boltzmann–Gibbs entropy required in the given case [5]. Further, the paper fails to distinguish between the concepts of entropy production (generation) and change of entropy, which is required when non-isolated systems are considered.

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